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FINAL REPORT

PHYSIOLOGICAL EFFECTS OF HEATING THE SKIN WITH MICROWAVE AND INFRARED RADIATION

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OBJECTIVE: The objective of this study has been to throw more light on the basic physiology and physiological pathology of heating the skin by means of radiant energy.

BRIEF SUMMARY OF RESULTS:

Initially, it was necessary to conduct basic research to elucidate the optical and thermal properties of human and animal skin. Spectrophometric measurements were made in the spectral region from 0.4 to 20μ for white, pigmented human skin and for animal skin. Thermal measurements were also necessary to determine the thermal diffusidity and thermal inertia of the skin. These studies were followed by the analysis of the effects of radiation to producing pain sensation, temperature sensation and thermal burns. From theoretical considerations, it was deduced that the temperature of the burn area following infliction on the burn was important as regards to pain, healing time and burn development. It would appear that these results have practical application in the problem of man's treatment of burns as well as in the hospital treatment of mild burns. Studies have also been carried out in respect to the heating of the skin by 3 cm and 10 cm microwave radiation. These results appear to have practical application in the problem of radiation safety to Navy personnel operating radar equipment.

Detailed descriptions of the experiments carried out under this contract and the analysis of the results is contained in the following progress reports and scientific publications:

a. Progress Reports:

1. January 13, 1954 - covering period 10-1-53 to 12-31-53
2. January 1, 1955 - " " 1-1-54 to 12-31-54
3. February 1, 1955 - " " 1-1-55 to 12-31-55
4. February 1, 1957 - " " 1-1-56 to 12-31-56
5. November 15, 1957 - " " 1-1-57 to 11- -57
6. November 11, 1958 - " " 11-15-57 to 11-14-58
7. July 28, 1960 - " " 1-5-59 to 1-5-60

b. Index of Technical Reports and Publications:

1. Benjamin, F. B.: Effect of histamine depletion on cutaneous pain threshold in man. Fed. Proc., 13:11, 1954.
2. Benjamin, F. B.: Effect of histamine releaser 48-80 on the inflammatory response in man. J. Applied Physiology, 7:151-153, 1954.
3. Benjamin, F. B.: Allergic contact dermatitis due to histamine releaser drug 48-80. Arch. Derm., 70-190-191, 1955.
4. Benjamin, F. B.: Interaction of pain and other sensations. Am. J. Med. Science, 230:226, 1955.
5. Benjamin, F. B.: Effect of pain on simultaneous perception of non-painful sensory stimulation. Journal of Applied Physiology, 8:30-34, 1956.
6. Benjamin, F. B. and C. Bailey: The effect of skin texture on the heating of the human skin by thermal radiation. J. Invest. Dermat., 26:472-477, 1956.
7. Benjamin, F. B. and C. Bailey: The effect of sweating and changes in blood flow on the heating of the human skin. Proc. Soc. Exper. Biol. and Med., 92:243-247, 1956.
8. Benjamin, F. B.: Release of intracellular potassium as the physiological stimulus for pain. Journal of Applied Physiology, 14 (4):643-646, 1959.

9. Clark, C. C., R. Vinegar and J. D. Hardy: Goniometric spectrometer for the measurement of diffuse reflectance and transmittance of skin in the infrared spectral region. Journal of Optical Soc. of America. Vol. 43, #11, 1953..

10. Greene, L. C.: Physical constants of human skin following thermal injury. Fed. Proc., 15-31, 1956.

11. Hardy, J. D.: Influence of thermal radiation of human skin. International Congress of Photobiology. August 1954 (Amsterdam).

12. Hardy, J. D.: Summary review of the influence of thermal radiation on human skin. NADC-MA-5415, 10-11-1954.

13. Hardy, J. D. and H. T. Hammel: Spectral transmittance and reflectance of white and pigmented human skin for wave lengths 0.5 - 2.8 micra. Fed. Proc., 14:69, 1955.

14. Hardy, J. D., H. T. Hammel and D. Murgatroyd: Spectral transmittance and reflectance of excised skin. J. Appl. Physiol., 9:257, 1956.

15. Hardy, J. D.: Influence of thermal radiation on man. Office of Naval Research, Decennial Vol. 1957.

16. Hardy, J. D.: The nature of pain. Journal of Chronic Diseases. 4:22-51, 1957.

17. Hardy, J. D., D. Cunningham, W. M. Benson: Modification of thermal radiation method for assessing antinociceptive activity in the rat. J. Appl. Physiology, 2:459-464, 1957.

18. Hardy, J. D., A. M. Stoll, D. Cunningham, W. M. Benson and L. Greene: Responses of the rat to thermal radiation. Am. Journal Physiol., 189:1, 1957.

19. Hardy, J. D., D. Murgatroyd, A. B. Keller: Warmth discrimination in dogs after a hypothalamic ablation. Am. J. Physiol., 195:276-284, 1958.

20. Hardy, J. D. and E. Hendler: Effective stimulus for warmth sensation in man. Am. Soc. of Mech. Engineers #59-A-208, 1959.

21. Hendler, E. and J. D. Hardy: Temperature sensations accompanying changes in skin temperature. NAMC-ACEL-350, 1957.

22. Hendler, E., R. Crosbie and J. D. Hardy: Measurement of heating of the skin during exposure to infrared radiation. J. Appl. Physiol., 12:177-185, 1958.

23. Hendler, E. and J. D. Hardy: Radiometric technique in skin temperature measurement. Inst. of Radio Engineers - 12th Annual Conf. on Elec. Techniques in Medicine and Biology. 1959.

24. Hendler, E. and J. D. Hardy: Some observations regarding temperature sensations due to microwave irradiation. Inst. of Radio Engineers - 12th Annual Conf. on Elec. Techniques in Medicine and Biology. 1959.

25. Hendler, E. and J. D. Hardy: Infrared and microwave effects on skin heating and temperature sensation. IRE Transactions on Medical Electronics. Vol. ME-7, July 1960.

26. Lipkin, M. and J. D. Hardy: Measurement and some thermal properties of human tissue. J. Appl. Physiol., 7:212-217, 1954.

27. Lipkin, M., C. Bailey and J. D. Hardy: Effect of ultraviolet irradiation upon the cutaneous pain threshold. J. Appl. Physiol., 7:633-637, 1955.

28. Murgatroyd, D., H. T. Hammel and J. D. Hardy: A new thermal pain threshold. Fed. Proc., 18:110, 1959.

29. Stoll, A. M.: Comparison of thermocouple and radiometric measurements of surface temperature during thermal radiation. Fed. Proc., 14:147, 1955.

30. Stoll, A. M. and L. C. Greene: Relationship between pain and tissue damage due to thermal radiation Journal of Applied Physiology, 11(3):373-382, 1959.

31. Stoll, A. M., L. C. Greene and J. D. Hardy: Pain and thermal burns in skin areas previously exposed to ultraviolet radiation. NADC-MA-5915, 1959.

32. Zitowitz, L. and J. D. Hardy: Influence of cold exposure on thermal burns in the rat. J. Appl. Physiol., 12:147-154, 1958.